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(71) Applicant
Galai Laboratories Ltd

(Incorporated in Israel)

Migdal Haemek 10500, Israel

(72) Inventors
Nir Hoffman
Avivi Karaslkov

(74) Agent and/or Address for Service
Baron & Warren
18 South End, Kensington, London, W8 5BU,
United Kingdom

(54) Particle size analyser

(57) A particle size analyzer for the determination of size of individual particles in the micron size range. The system for effecting the analysis comprises a laser 11 and means 12 for collimating the laser beam, a rotating wedge prism 14 for converting this beam to a circular rotation beam, focusing means 15 for focusing the beam to a fine point, a transparent carrier 17 for supporting the particles to be analyzed, and a photosensitive cell located behind the particle carrier. The laser beam interacts with the particles and the resulting signals, from each such interaction, are analyzed to provide information on particle size. The preferred analysis is based on the time of transition theory. The carrier is capable of being moved in the X-Y directions so that the entire area of the carrier may be analysed.

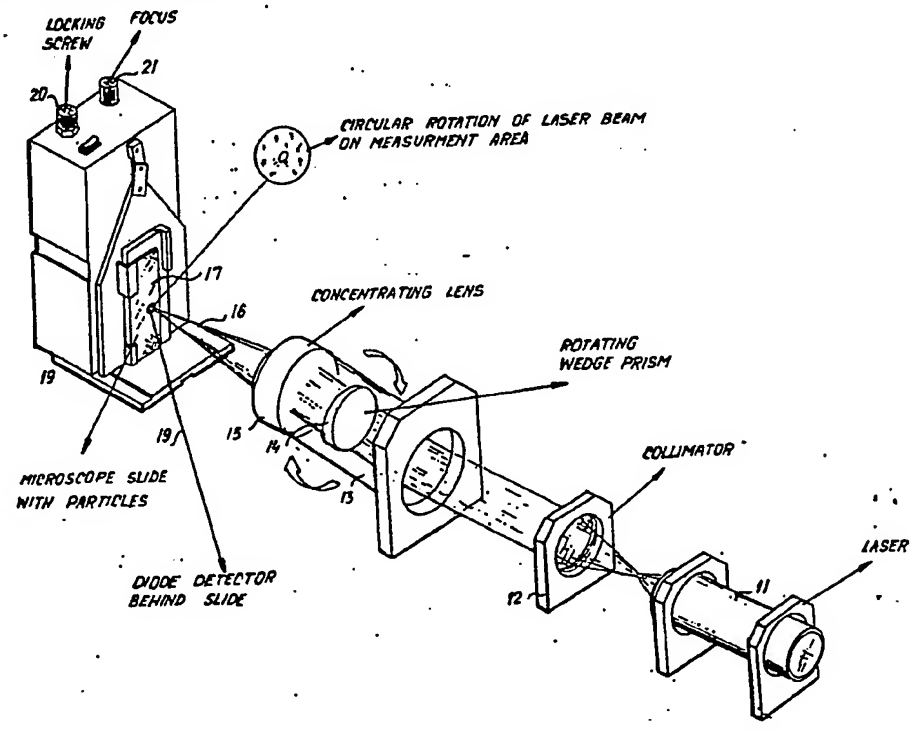

FIG. 1

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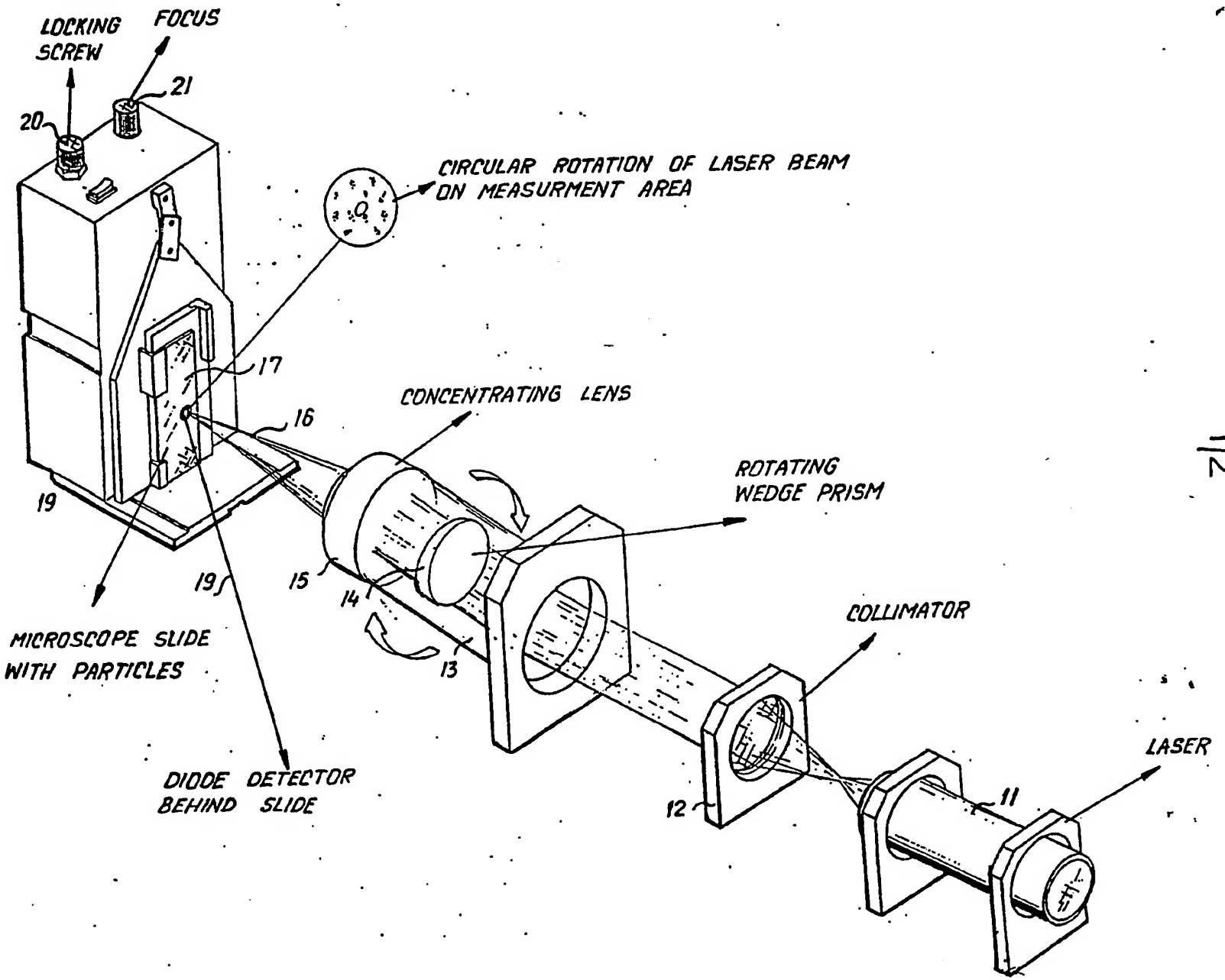
LOCKING SCREW
FOCUS
21
20
CIRCULAR ROTATION OF LASER BEAM ON MEASURMENT AREA
17
16
CONCENTRATING LENS
ROTATING WEDGE PRISM
19
19
15
14
13
MICROSCOPE SLIDE WITH PARTICLES
DIODE DETECTOR BEHIND SLIDE
COLLIMATOR
LASER
12
11

FIG. 1

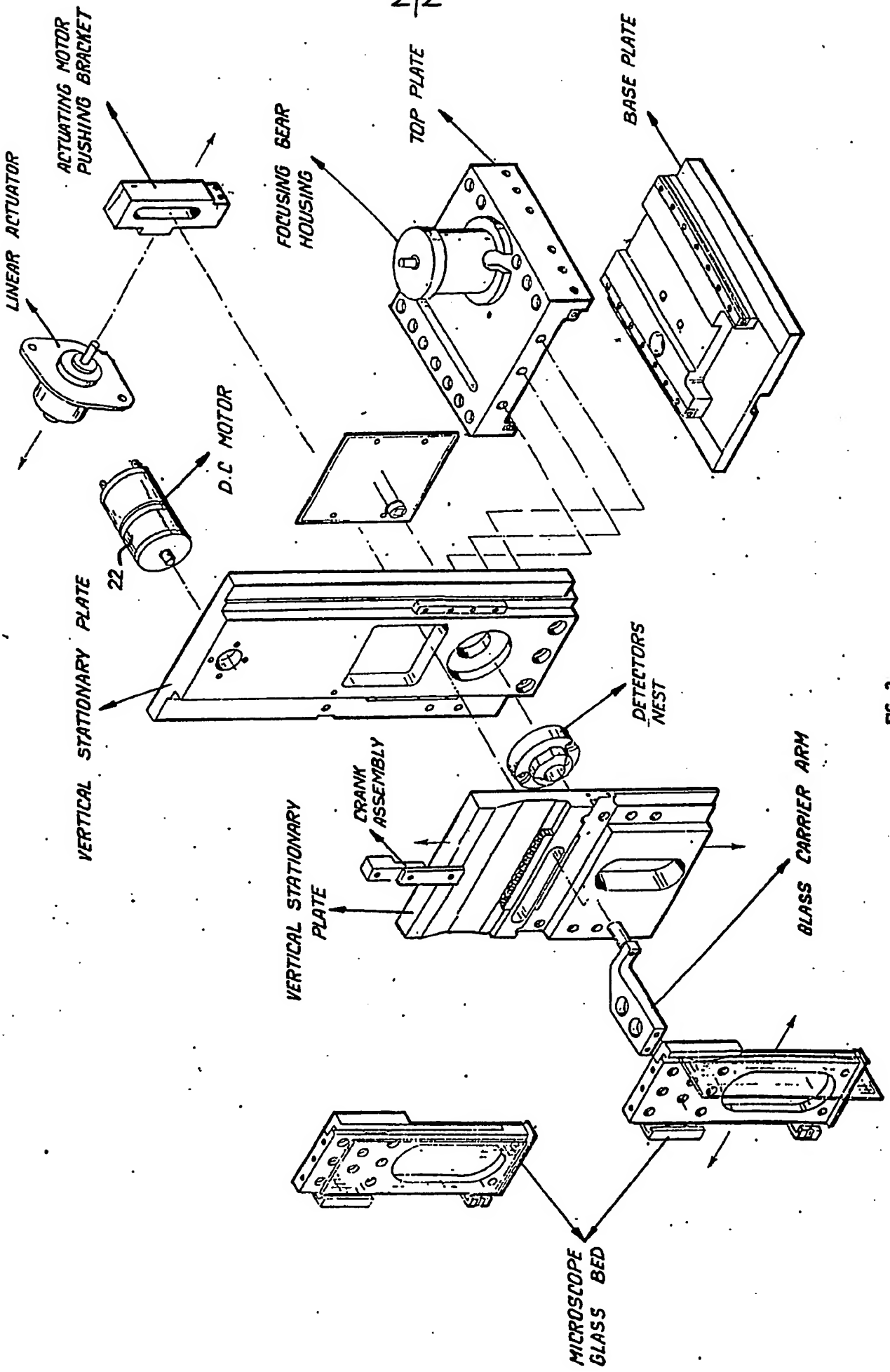
ACTUATING MOTOR PUSHING BRACKET
LINEAR ACTUATOR
FOCUSING GEAR HOUSING
TOP PLATE
BASE PLATE
D.C MOTOR
22
VERTICAL STATIONARY PLATE
DETECTORS NEST
CRANK ASSEMBLY
VERTICAL STATIONARY PLATE
GLASS CARRIER ARM
MICROSCOPE GLASS BED

FIG. 2

PARTICLE SIZE ANALYZER

The invention relates to a novel versatile particle analyzer system. The system is based on the use of a laser scanning mechanism, which analyzes particles which are deposited on a suitable support. The system can also be used for the analysis of stirred or flowing aerosols: The particle size analysis is based on the time of transition theory.

A large variety of particle analyzers are known and also commercially available. Simple ones are based on the scanning and counting of particles on a glass slide. On the other hand there are known rather complicated and expensive measurement systems for use with aerosols. The present invention provides a comparatively simple system which allows for the rapid and accurate particle size analysis.

The invention relates to a laser scanning particle size analysis system. The novel system is based on the interaction between the scanning laser beam and a particle, resulting in a signal picked up by suitable detection means. The particle size analysis is based on the time of translation theory.

A preferred embodiment of the system of the invention relates to an integrated system for particle size analysis of particles which are stationary on a suitable transparent support such as a glass slide. There is used a scanner, which will be described furtheron, in combination with a preprogrammed motorized mechanical cell which allows the

X-Y scanning of the complete surface of the slide by the laser beam, which interacts with the particles, while at the same time maintaining a constant focus of the said beam.

The present invention relates to a system which can be used for the size analysis of a variety of particles, and even of droplets. It is of special use for the analysis of dry powders which are spread out on the surface of a slide. It can be used for particle size determination of rather concentrated dispersions, which can also be opaque, and which are spread on the slide in a thin layer before this layer is evaluated.

The system uses a laser such as a finely focused He-Ne laser of 3 mW for the time of transition measurements. A wedge prism is rotated at a constant speed, and, as individual particles on the slide are bisected by the "flying spot" of the laser, reaction signals are detected by a PIN photodiode or similar photoelectric sensor. As the rotationalal velocity is constant, the duration of each interaction, i.e. the time of transit of the focused beam across each particle relates solely and uniquely to the size of the particle and not to any other property of same. Experiments have shown that the system of the invention is of use in the range of from about 0.5 µ to about 1200 µ size particles. The slide is held by a special mechanism and moved along the X-Y axes,, thus making possible a scan of any part of the slide, or of its entire surface. The movement of the slide for each line scan will generally be according to the size of the field scanned by the beam so as to prevent overlap of counts and size determinations.

Interaction signals are collected and analyzed by a dedicated data acquisition board, in a personal computer.

Means are provided for an automatic focusing of the laser beam on the surface of the particle carrier after this is inserted and secured to its holder. There can also be used manual focusing means provided in the system, where the operator uses a knob allowing easy manipulation,and which uses a high ratio gear, such as 1:100 to allow a very sensitive and high accuracy setting and focusing.

The slide cell module is advantageously equipped on its X-Y axis with "micro-slides" cross roller bearings, which result in a very low friction. The bearings are generally preloaded giving zero side and vertical play.

The end of the linear scan can be controlled by means of an "opto-scanner" or "opto-coupler" which automatically reverses the direction of movement of an actuator motor which is used for the movement. Once the limit of the slide movement is reached, the direction of movement is reversed, after making a suitable movement in the vertical direction,resulting in a scan of a predetermined surface of the slide.

The novel system allows for the particle size determination in a large number of systems, and even in smears, pastes and the like. The slide moves in front of the rotating scanner laser beam, using the theory of Time of Transition in a photo-defined measurement zone. This results in a high resolution and accuracy of measurement. The device set out above can be used in conjunction with another system,where the same slide, after completion of measurement, to video shape analysis, bringing the full power of computerized

image analysis to complete the characterization of particle size and shape.

The invention is illustrated by way of example only with reference to the enclosed schematical drawings, which are not according to scale, and in which:

Fig. 1 is an exploded perspective view of a system of the invention;

Fig. 2 is an exploded view of the slide holder and its part, the various parts being shown and identified in the Figure.

As illustrated with reference to the Figures, the system of the invention comprises a laser 11, the beam of which passes via collimator 12 to unit 13 wherein there is provided a rotating wedge prism, 14, in front of which there is provided concentrating lens 15, which provide together a focued laser beam 16 on slide 17 which holds the sample to be measured on its surface. The wedge prism, which rotates at a constant velocity, scans the laser beam circularly, which scans the slide surface, which is located in font of a pin photodiode detector 19, behind the slide 17. The circular rotation of laser beam 16 on the measurement area is illustrated by Figure 1-A.

The slide holding cell 19 is provided with means for the secure holding of the slide 17, which supports the particles, with a locking screw 20, a focusing knob 21 and with various moving parts, the actuation being by means of a DC motor 22 shown in Fig. 2. The output of the photodiode provides counts of the particles and information on their size.

The evaluation is made as set out above.

The above description is by way of illustration and various changes and modifications can be made within the scope of the present invention.

Figure 2, illustrates a slide holder for use in the system of the invention. It comprises, as shown in the exploded view, a base plate 23, and a top plate 24, to which there is attached a focusing gear housing 25, there being provided a vertical stationary plate 26, with an opening for the detectors nest 27, and another for the axis of motor 22, which actuates linear actuator 28 with actuating motor pushing bracket 29. The vertical plate 26 engages vertical moving plate 30 with crank assembly 31 and glass carrier arm 32 and microscope glass bed 33. The slide holder illustrated operates in a simple manner and gives very satisfactory results.

The CIS-1 Galai system comprises a second measurement channel based on a video device such as a CCD camera. Microscope images of the particles in the field of view of the camera can be acquired by a frame grabber and analyzed by a sophisticated image analysis software program, to provide data on the shape, size and aggregates of the sample.

The video microscope channel is advantageously located perpendicular to the laser beam channel. For use, the microscope slide is inserted into a support channel which is perpendicular to the first position, as shown in Fig.2. The slide is scanned at a rate of about 40 mm/min in the Y-direction, by the same mechanism used in the laser channel measurements.

A wide range of particle concentrations can be evaluated, and generally the scan of the entire surface of the microscope slide takes about 5 to 10 minutes.

CLAIMS:

1. A particle size analyzer comprising in combination a laser, a collimator for collimating the laser light beam, a rotating wedge prism for obtaining a circular rotation laser beam, a lens for focusing the beam to a small size focus, a transparent carrier supporting the particles to be analyzed and a photosensitive cell located behind the particle carrier, means for picking up the signals during the interaction of the particles and the focused beam and means for effecting the particle size analysis based on the time of transition theory.

2. A system according to claim 1, where the particle carrier is supported by a stage permitting predetermined movement in the X-Y plane, the scanning being along one of these coordinates, moving to another adjacent strip and scanning this strip and determining the particle size and number.

3. A system according to claim 1 or 2, where means are provided for the accurate focusing of the laser beam and for maintaining such focus in the plane of the particle carrier.

4. A system according to any of claims 1 to 3, where there are provided means for rotating the wedge prism at a constant speed so that the passage of the laser beam across each particle relates solely to the size of the particle.

5. A system according to any of claims 1 to 4, where the particle/beam interaction signals are collected and analyzed by a dedicated data acquisition board in suitable computing means.

6. Particle size analyzer based on the use of an X-Y stage which can be moved according to a preprogrammed manner, based on a rotating laser beam foused on the plane of the slide carrying the particles, substantially as hereinbefore described and with reference to the Figures.

7. A particle size analyzer according to any of claims 1 to 6, provided with a further channel based on a video device (CCD or the like), a frame grabber for acquiring the image of the microscope field, and means to analyze the particles as regards size, shape and aggregates.

8. A particle size analyzer substantially as hereinbefore described with reference to the accompanying drawings.

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